

Doc 9911

# Recommended Method for Computing Noise Contours Around Airports

Approved by the Secretary Ceneral and published under his authority

First Collion - 2003

International Civil Aviation Organization

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## **Recommended Method for Computing Noise Contours Around Airports**

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First Edition — 2008

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Published in separate English, Arabic, Chinese, French, Russian and Spanish editions by the INTERNATIONAL CIVIL AVIATION ORGANIZATION 999 University Street, Montréal, Quebec, Canada H3C 5H7

For ordering information and for a complete listing of sales agents and booksellers, please go to the ICAO website at <u>www.icao.int</u>

First edition 2008

ICAO Doc 9911, Recommended Method for Computing Noise Contours Around Airports Order Number: 9911 ISBN 978-92-9231-225-1

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#### AMENDMENTS

Amendments are announced in the supplements to the Catalogue of ICAO *Publications;* the Catalogue and its supplements are available on the ICAO website at <u>www.icao.int</u>. The space below is provided to keep a record of such amendments.

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### FOREWORD

This manual on Recommended Method for Computing Noise Contours Around Airports (Doc 9911) replaces similar material contained in Recommended Method for Computing Noise Contours Around Airports (Circular 205), which was approved by the ICAO Committee on Aviation Environmental Protection (CAEP) at its first meeting in 1986

This first edition of Doc 9911 contains material developed by CAEP with the assistance of aviation stakeholders, including regulatory authorities, air traffic management providers, airport operators, manufacturers, airline associations and airlines, as well as the ICAO Secretariat. It was approved by CAEP at its seventh meeting in February 2007

This manual is intended to assist States in the computation of noise contours around airports, using the most up-to-date procedures and the most recent aircraft noise and performance information available. It describes the major aspects of the calculation of noise contours for air traffic at an airport including three different ways in which most practical noise models calculate aeroplane single event noise levels.

This new manual is an important advance on the previous Circular in that it is linked to an international aircraft noise and performance (ANP) database which is accessible online at <a href="http://www.aircraftnoisemodel.org">http://www.aircraftnoisemodel.org</a> The methodology described in the manual is designed to make full use of this data source, which has been assembled over many years by aircraft manufacturers in collaboration with noise certification authorities and is fully endorsed by ICAO

It is intended that this manual be kept up to date Future editions will be improved on the basis of work by CAEP and of comments and suggestions received from the users of the manual Users are therefore invited to give their views, comments and suggestions on this edition, which should be directed to the Secretary General of ICAO

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### **EXPLANATION OF TERMS AND SYMBOLS**

#### **DEFINITION OF TERMS**

Note — In keeping with established practice in the field of aeroplane noise modelling, the units of measurement used in this document do not necessarily accord with the recommendations of ICAO Annex 5 — Units of Measurement to be Used in Air and Ground Operations

When the following terms are used in this document, they have the following meanings

AIP. Aeronautical Information Publication

Aeroplane configuration. The positions of slats, flaps and landing gear

- Aeroplane movement. An arrival, departure or other aeroplane action that affects noise exposure around an aerodrome
- Aeroplane noise and performance data. Data describing the acoustic and performance characteristics of different aeroplanes types that are required by the modelling process. They include noise-power-distance (NPD) relationships and information that allows engine thrust/power to be calculated as a function of the flight configuration. The data are usually supplied by the aeroplane manufacturer although when that is not possible it is sometimes obtained from other sources. When no data are available, it is usual to represent the aeroplane concerned by adapting data for a suitably similar aeroplane this is referred to as substitution.

Altitude. Height above mean sea level

ANP database. The international aircraft noise and performance database www aircraftnoisemodel org

A-weighted sound level, L<sub>A</sub>. Basic sound/noise level scale used for measuring environmental noise including that from aeroplanes and on which most noise contour metrics are based

Backbone ground track. A representative or nominal ground track which defines the centre of a swathe of tracks

Baseline noise event level. The noise event level read from an noise-power-distance (NPD) database

- Brake release Start-of-roll
- Corrected net thrust. At a given power setting (e.g. EPR or N1) net thrust falls with air density and thus with increasing aeroplane altitude, corrected net thrust is the value at sea level
- Cumulative sound/noise level. A decibel measure of the noise received over a specified period of time, at a point near an airport, from aeroplane traffic using normal operating conditions and flight paths. It is calculated by accumulating the event sound/noise levels occurring at that point
- Decibel sum or average Sometimes referred to elsewhere as "energy" or "logarithmic" (as opposed to arithmetic) values Used when it is appropriate to sum or average the underlying energy-like quantities, e.g. decibel sum

Energy fraction, F. Ratio of sound energy received from a segment to energy received from infinite flight path

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- Engine power setting. Value of the noise related power parameter used to determine noise emissions from the noisepower-distance (NPD) database.
- Equivalent (continuous) sound level, Leq. A measure of long-term sound The level of a hypothetical steady sound, which over a specified period of time, contains the same total energy as the actual variable sound.
- Event sound/noise level. A decibel measure of the finite quantity of sound (or noise) received from a passing aeroplane sound exposure level.
- Flight configuration. Equals aeroplane configuration plus flight parameters.
- Flight parameters. Aeroplane power setting, speed, bank angle and mass.
- Flight path (or trajectory). A full description of the motion of the aeroplane in space (three dimensions) and time, which is accounted for via aeroplane speed. The flight path of an aeroplane is typically referenced to an origin at the start of the take-off roll or at the landing threshold.
- Flight path segment. Part of an aeroplane flight path represented for noise modelling purposes by a straight line of finite length.
- Flight procedure. The sequence of operational steps followed by the aeroplane crew or flight management system: expressed as changes of flight configuration as a function of distance along the ground track.
- Flight profile. A description of the aeroplane motion in the vertical plane above the ground track, in terms of its position, speed, bank angle and engine power setting (sometimes also includes changes of flight configuration), described by a set of profile points.
- Ground plane (or nominal ground plane). Horizontal ground surface through the aerodrome reference point on which the contours are normally calculated.
- Ground speed. Aeroplane speed relative to a fixed point on the ground.
- Ground track. Vertical projection of the flight path onto the ground plane.
- Height. Vertical distance between aeroplane and ground plane.

Integrated sound level. Otherwise termed "single event sound exposure level".

- International Standard Atmosphere (ISA). Defines variation of air temperature, pressure, and density with height above mean sea level. Used to normalize the results of aeroplane design calculations and to analyse test data. Defined by ICAO [ref. 11].
- Lateral attenuation. Excess attenuation of sound with distance attributable, directly or indirectly, to the presence of the ground surface. Significant at low angles of elevation (of the aeroplane above the ground plane).

Mass. The quantity of matter (in an aircraft).

Maximum noise/sound level. The maximum sound level reached during an event.

Mean sea level (MSL). The standard earth surface elevation to which the ISA is referred.

Net thrust. The propulsive force exerted by an engine on the airframe.

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- Noise. Noise is defined as unwanted sound. But metrics such as A-weighted sound level (L<sub>A</sub>) and effective perceived noise level (EPNL) effectively convert sound levels into noise levels. Despite a consequent lack of rigour, the terms "sound" and "noise" are sometimes used interchangeably in this document.
- Noise contour. A line of constant value of a cumulative aeroplane noise level or index around an airport
- Noise impact. The adverse effect(s) of noise on its recipients, importantly, it is implied that noise metrics are indicators of noise impact
- Noise index. A measure of long-term or cumulative sound which correlates with (i e is considered to be a predictor of) its effects on people. Other factors may be taken into account including the magnitude of the sound (especially time of day). An example is day-evening-night level, L<sub>DEN</sub>
- **Noise level.** A decibel measure of sound on a scale which indicates its loudness or noisiness. For environmental noise from aeroplanes, two scales are generally used. A-weighted sound level and perceived noise level. These scales apply different weights to sound of different frequencies to mimic human perception.
- Noise metric. An expression used to describe any measure of quantity of noise at a receiver position whether it be a single event or an accumulation of noise over extended time. There are two commonly used measures of single event noise, the maximum level reached during the event, or its sound exposure level, which is a measure of its total sound energy determined by time integration.
- Noise-power-distance (NPD) data. Noise event levels tabulated as a function of the distance below an aeroplane in steady level flight at a reference speed in a reference atmosphere, for each of a number of *engine power settings*. The data account for the effects of sound attenuation due to spherical wave spreading (inverse-square law) and atmospheric absorption. The distance is defined perpendicular to the aeroplane flight path and the aeroplane wing-axis (i.e. vertically below the aeroplane in non banked level flight).
- Noise-related power parameter, power or power setting. Parameters that describe or indicate the propulsive effort generated by an aeroplane engine to which acoustic power emissions can logically be related, usually taken to be corrected net thrust
- Noise significance. The contribution from a flight path segment is "noise significant" if it affects the event noise level to an appreciable extent
- Observer. Receiver
- Procedural steps. Prescription for flying a profile --- steps include changes of speed and/or altitude
- Profile point. Height of flight path segment end point --- in vertical plane above the ground track
- Receiver. A recipient of noise that arrives from a source, principally at a point on or near the ground surface
- Reference day. A set of atmospheric conditions on which ANP data are standardized
- **Reference duration.** A nominal time interval used to standardize single event sound exposure level measurements, equal to 1 second in the case of SEL
- Reference speed. Aeroplane ground speed to which noise-power-distance (NPD) sound exposure level (SEL) data are normalized
- SEL. Sound exposure level

- Single event sound exposure level. The sound level an event would have if all its sound energy were compressed uniformly into a standard time interval known as the "reference duration".
- Soft ground. A ground surface that is acoustically "soft", typically grassy, that surrounds most aerodromes. Acoustically hard, i.e. highly reflective, ground surfaces includes concrete and water. The noise contour methodology described herein applies to soft ground conditions.
- **Sound.** Energy, or acoustic energy. The squared sound pressure (often frequency weighted), divided by the squared reference sound pressure of 20 µPa, the threshold of human hearing. It is algebraically equivalent to 10<sup>L/10</sup>, where L is the sound level, expressed in decibels.
- **Sound attenuation.** The decrease in sound intensity with distance along a propagation path. For aeroplane noise, its causes include spherical wave spreading, atmospheric absorption and lateral attenuation.

Sound exposure. A measure of total sound energy emission over a period of time.

- Sound exposure level, L<sub>AE</sub> or SEL. A metric standardized in ISO 1996-1 [ref. 14] or ISO 3891 [ref. 15] = A-weighted single event sound exposure level referenced to 1 second.
- Sound intensity. The strength of sound emission at a point related to sound energy (and indicated by measured sound levels).
- Sound level. A measure of sound energy expressed in decibels. Received sound is measured with or without "frequency weighting"; levels measured with a weighting are often termed "noise levels".

Stage/trip length. Distance to first destination of departing aeroplane; taken to be an indicator of aeroplane mass.

- Start-of-roll (SOR). The point on the runway from which a departing aeroplane commences its take-off. Also termed "brake release".
- True airspeed. Actual speed of aeroplane relative to air (= ground speed in still air).
- Weight. The downward force of gravity exerted on an aeroplane. It is essentially proportional to the aeroplane's mass. Note, although strictly different entities, the terms "weight" and "mass" are used interchangeably throughout this document.
- Weighted equivalent sound level, L<sub>eq,W</sub>. A modified version of L<sub>eq</sub> in which different weights are assigned to noise occurring during different periods of the day (usually day, evening and night).

#### SYMBOLS

The mathematical symbols provided in the following list are the main ones used in the equations throughout this manual; they have the following meanings:

- d Shortest distance from an observation point to a flight path segment
- d<sub>p</sub> Perpendicular distance from an observation point to the flight path (slant distance or slant range)
- d<sub>λ</sub> Scaled distance
- Fn Actual net thrust per engine
- $F_n/\delta$  Corrected net thrust per engine
- h Aeroplane altitude (above MSL)
- L Event noise level (scale undefined)